

# PATENT ABSTRACTS OF JAPAN

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## (54) PLASMA TREATMENT APPARATUS

(57)Abstract:

PROBLEM TO BE SOLVED: To miniaturize the entire body of an apparatus, expand applicability to a variety of objects to be treated, make it easy to assemble the apparatus in an in-line of a production process, considerably lower the production cost by simplifying the electrode part constitution, and properly, evenly and remarkably efficiently carry out a prescribed surface treatment.

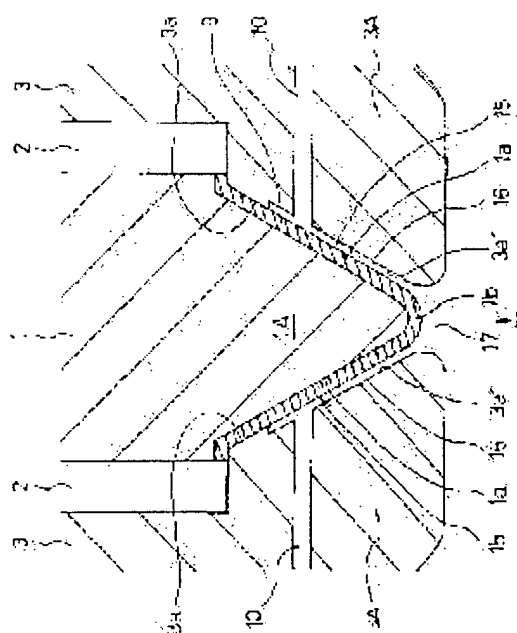
SOLUTION: This plasma treatment apparatus is provided with a high voltage electrode 1 formed in the solid belt-like shape and a pair of grounded electrodes 3, 3 set face of face while sandwiching insulating plates 2, 2 in both sides in the thickness direction and the one end part 1A in the short side of the high voltage electrode 1 is so formed as to form approximately isosceles triangle shape having

inclining faces 1a, 1a. Electric discharge gaps 15, 15 and inclining faces 3a', 3a' composing the passages 16, 16 for blowing gas currents containing chemically active and excited seeds generated by electric discharge plasma are installed in the one end parts 3A, 3A sides in the width direction of the earthing electrodes 3, 3 where a reaction gas supply passage 6 is formed in the solid inside on the opposite to the inclining faces 1a, 1a in both sides of the high voltage electrode 1 side.

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to a plasma treatment apparatus, and in detail, When applying a paint to the resin which mainly has water repellence, such as



polyethylene, polypropylene, PTFE (polytetrafluoroethylene), or printing by a water-based ink, reform the surface to hydrophilic nature, or, It is related with the plasma treatment apparatus used when performing the surface treatment of the plasma treatment of oxygen giving wettability on the surface of a plastic, carrying out hydrophilization of the hydrophobic surface of glass, ceramics, metal, a semiconductor, etc., or washing the organic matter adhering to the surface.

[0002]

[Description of the Prior Art]As a plasma treatment apparatus used for surface treatments, such as the above surface treatment and organic matter washing, The reactant gas which mixes reactant gases, such as inactive gas and oxygen, such as helium and hydrogen, and fluorine-containing compound gas of a fluorocarbon system, under atmospheric pressure or the pressure near the atmospheric pressure (weak decompression or weak application of pressure) between a high voltage electrode and an earth electrode. By impressing high frequency voltage to two electrodes, while introducing into the discharge section formed and passing it. As an atmospheric pressure plasma treatment apparatus constituted so that the gas stream which makes a discharge section generate glow discharge plasma, and is generated by this plasma, and which includes an activity excitation kind chemically might be turned on the surface of a processed material, might be made to blow off and a predetermined surface treatment might be performed, For example, the thing of composition as indicated by the patent No. 2589599 gazette and the patent No. 2934852 gazette is already proposed from before.

[0003]Realization of the surface treatment under atmospheric pressure is possible for the plasma treatment apparatus proposed from these former, A processing unit by the low-pressure glow discharge plasma adopted from it or before, For example, low-pressure glow discharge plasma is generated by making the discharge section between the high voltage electrode and earth electrode which have been mutually arranged to the opposed state introduce the reactant gas for discharge, such as oxygen, in a vacuum housing, and impressing high frequency voltage to two electrodes, It compares with the plasma processing unit constituted so that the surface of the processed material which carried out installation maintenance might be processed on an earth electrode by the gas which is generated by this plasma, and which includes an activity excitation kind chemically, Since the device for forming a vacuum system and equipment are unnecessary, while being able to attain a miniaturization and low-cost-izing of the whole device, Since it is not necessary to install a processed material on an electrode, it has the advantage that the in-line nest of a production process is also easy, and improvement in productivity can also be aimed at that it is easy to make it correspond to the area and thickness of a processed material, and shape, and can apply to the surface treatment to a variety of processed materials.

[0004]

[Problem(s) to be Solved by the Invention]The atmospheric pressure plasma treatment apparatus currently indicated by the former patent No. 2589599 gazette among the plasma treatment apparatus by which the conventional proposal is made, While forming the reactant gas supply path of double duct structure in the box-like discharge section by which the end was blockaded, It is a thing in which it makes it come to form the tubed discharge space which for [ two or more pairs ] arranges thin tabular the high voltage electrode and earth electrode of a couple via an insulation material separator to the open lower end part side in a case shape discharge section, and where opening connection of the above-mentioned reactant gas supply path is made inter-electrode [ the ], Since the composition of the polar zone enters very intricately, a

manufacture assembly is dramatically difficult, The cost of the whole device not only becomes expensive, but it is easy to generate abnormal discharge, such as a spark and arc discharge, and there is a problem that generating of the glow discharge plasma under atmospheric pressure becomes unstable easily by the power loss accompanying this abnormal discharge.

[0005]On the other hand, the atmospheric pressure plasma treatment apparatus currently indicated by the latter patent No. 2934852 gazette, The general-purpose processing means of hole down processing inside [ the ] inner substance, and slit processing to the both side surfaces of the thickness direction using a single inner substance batten-plate-shape high voltage electrode, It is possible to constitute the polar zone provided with the supply function and the gas stream jet function of approximately linear shape of mixing reaction gas from a simple assembly means to pile up the earth electrode of a couple on the both sides of the thickness direction of a high voltage electrode on both sides of an electric insulating plate, While the composition of the whole polar zone is dramatically easy and being able to aim at reduction of a manufacturing cost compared with the former atmospheric pressure plasma treatment apparatus, the power loss accompanying abnormal discharge, such as a spark, can also be controlled.

[0006]However, in the atmospheric pressure plasma treatment apparatus currently indicated by the latter patent No. 2934852 gazette. Two or more slit shape gas blowout holes of approximately semicircle shape are formed in each both side surfaces of the thickness direction of an inner substance batten-plate-shape high voltage electrode in fragments along the long side direction of a high voltage electrode, By arranging the slit shape gas blowout hole of these thickness direction both side surfaces so that it may be alternately located along with a longitudinal direction. It is constituted so that the gas stream which was generated with generating of discharge plasma and which includes an activity excitation kind chemically may be spouted to approximately linear shape on the surface of a processed material, Also although a general-purpose processing means is told to condition of forming so that the hole of both sides may be alternately located in each thickness direction both side surfaces of a high voltage electrode along a long side direction in the slit shape gas blowout hole of two or more approximately semicircle shape, it takes great and highly precise manufacture processing technology, and there is a limit also in reduction of a manufacturing cost. Although a gas stream blows off to approximately linear shape to the surface of a processed material on the whole, since it is what blows off from the slit shape gas blowout hole currently actually formed in approximately semicircle shape in fragments to the thickness direction both side surfaces of a high voltage electrode, It is difficult not to break off and to make the gas stream which blows off from each blowout hole form in straight line shape, and it tends to generate dispersion in the surface treatment of a processed material. In order to lose such dispersion, it is necessary to make the feed rate of a processed material late, and the room of improvement is left behind in the field of processing efficiency.

[0007]This invention was made in view of the above actual condition, and The miniaturization of the whole device, While the composition of the polar zone is dramatically easy and being able to attain sharp reduction of a manufacturing cost from the first, that ease of the nest of a production process the expansion of applicability to a variety of processed materials and in-line can be planned, The power loss by abnormal discharge can also be controlled and it aims at providing the plasma treatment apparatus which can make a jet gas style able to form in the processed material surface in a straight line certainly, and can moreover perform a

predetermined surface treatment uniformly and very efficiently.

[0008]

[Means for Solving the Problem] To achieve the above objects, a plasma treatment apparatus concerning this invention, On both sides of a thickness direction (the direction of x-x) of a high voltage electrode (1) currently formed in inner substance batten plate shape, respectively An electric insulating plate (2), A placed opposite is carried out by the earth electrode (3) and (3) of a couple on both sides of (2), and an end side portion (1A) of a short side direction (the direction of z-z) of the above-mentioned batten-plate-shape high voltage electrode (1), While being formed an inclined plane (1a) which is approached gradually, and in the shape of [ used as (1a) ] an approximately isosceles triangle so that the both side surfaces approach a tip part, inside an earth electrode (3) of the above-mentioned couple, and (3), While a supply path (6) of mixing reaction gas with a reactant gas containing fluorine-containing compound gas of inactive gas, oxygen, or a fluorocarbon system which makes the long side direction (the direction of y-y) meet, and contains helium or hydrogen at least is formed, an earth electrode (3) of these couples, To the end part side of a short side direction (the direction of z-z) of (3), respectively A both-sides inclined plane of an approximately isosceles triangle-like portion (1A) of the above-mentioned high voltage electrode (1) (1a), an inclined plane (3a) which makes (1a) counter and constitutes a discharge gap (15) and a mixing reaction gas blow-off passage (16), and (3a) being formed, and, To the above-mentioned reactant gas supply path (6) so that free passage connection may be made at an inclined plane (3a) of an earth electrode (3) of these couples, and (3), and (3a) Each earth electrode (3), The opening of two or more mixed gas blowout holes (10) which separated and formed an interval in a long side direction (the direction of y-y) of (3) is carried out, A both-sides inclined plane of an approximately isosceles triangle-like portion (1A) of the above-mentioned high voltage electrode (1) (1a), An inclined plane of the whole surface containing (1a) and an earth electrode (3) of a couple, and (3) (3a), At least one side of the whole surface containing (3a) is covered with an insulator (9), An inclined plane of the above-mentioned two electrodes (1) from two or more above-mentioned gas blowout holes (10), (3), and (3) (1a), (3a) While making a both-sides discharge gap (15) of formation in between, and a mixing reaction gas blow-off passage (16) introduce and pass the above-mentioned mixing reaction gas under atmospheric pressure or a pressure near the atmospheric pressure, by impressing high frequency voltage to the above-mentioned two electrodes (1), (3), and (3), Generate the above-mentioned both-sides discharge gap (15), and glow discharge plasma by this plasma. It constitutes so that it may spout to linear shape on the surface of a processed material (13) from a blow-off part (17) which provided a gas stream which is generated, and which includes an activity excitation kind chemically in the downstream of a both-sides blow-off passage (16).

[0009] According to this invention of the above-mentioned composition, it is possible to constitute polar zone provided with a supply function and a straight line shape gas stream jet function of mixing reaction gas from a simple assembly means to pile up an earth electrode of a couple on both sides of a thickness direction of a batten-plate-shape high voltage electrode on both sides of an electric insulating plate. By this, compared with a processing unit by low-pressure glow discharge plasma, a miniaturization of the whole device, Area, thickness, shape, etc. the ease of a nest of a production process expansion of applicability to a variety of processed materials, and in-line, of course, While composition of the whole polar zone is dramatically easier compared with an atmospheric pressure plasma treatment apparatus of a proposal than

before, sharp reduction of the whole manufacturing cost can be aimed at by reduction of work processes, and unnecessary-ization of highly precise processing technology. Since it is the composition which power loss accompanying abnormal discharge, such as a spark and arc discharge, does not produce easily, it is easy to stabilize generating of glow discharge plasma under atmospheric pressure.

[0010]Furthermore, It is introduced into both discharge gaps and a blow-off passage which are formed along a both-sides inclined plane of an approximately isosceles triangle-like portion by the side of an end of a short side direction of a high voltage electrode, pass, and by glow discharge plasma. By blowing off and making the generated gas streams which include an activity excitation kind chemically blow off from a blow-off part of the passage downstream towards the surface of a processed material, It can be possible to make a gas stream of straight line shape which is not which breaks off by the collision of these jet gas styles act uniformly throughout the surface of a processed material, and a predetermined surface treatment can be made to perform in a usual state efficiently properly uniformly at an emergency.

[0011]Like a statement to claim 2 as an insulator which covers at least one side of the whole surface which includes the whole surface including a both-sides inclined plane of an approximately isosceles triangle portion by the side of a short side direction end of the above-mentioned batten-plate-shape high voltage electrode, and an inclined plane of an earth electrode of a couple in a plasma treatment apparatus which operates as mentioned above, When adopting a means to form by ceramic coating, positive pre-insulation which a generation cause of a spark does not generate to an opposite inclined plane of two electrodes can be performed easily, a protective effect of an electrode can be heightened, and improvement in endurance can be aimed at.

[0012]In a plasma treatment apparatus of the above-mentioned composition, like a statement to claim 3, When making an inside of an earth electrode of a couple, and an inner substance batten-plate-shape high voltage electrode meet those long side directions and forming a passage for cooling water flows in it, respectively, Even if it does not adopt special composition, such as a double duct, it is possible to form a passage for cooling water flows in a case of a reactant gas supply path and the appearance by hole dawn processing at each electrode itself, It is possible to prevent electrode overheating at the time of covering a long time and performing a surface treatment, and to perform a predetermined surface treatment efficiently continuously, simplifying polar-zone composition more and aiming at much more reduction of a manufacturing cost.

[0013]In a plasma treatment apparatus of the above-mentioned composition, like a statement to claim 4, Intersecting angles of a both-sides inclined plane of an approximately isosceles triangle-like portion by the side of a short side direction end of the above-mentioned batten-plate-shape high voltage electrode, When the gas streams which pass and blow off set a both-sides discharge gap and blow-off \*\*\*\*\* as an angle which collides and joins rather than the above-mentioned blow-off part in a jet direction downstream position, Collision unification of the gas streams can be carried out on the surface of a processed material, and equalization of a surface treatment and further improvement in processing efficiency can be attained.

[0014]In a plasma treatment apparatus of the above-mentioned composition, like a statement to claim 5, By providing a covering casing which surrounds the above-mentioned high voltage electrode, an earth electrode, and an insulator, and having composition which built into one a consistency machine which adjusts an RF generator and a high voltage electrode in this covering casing, It is possible to carry out direct attachment of a consistency machine and the power supply terminal of an

electrode also electrically and physically, While reducing power loss in a high frequency (not less than 100 kHz) high power operating mode and being able to attain stabilization of plasma treatment especially, Free nature can be given to a using form of this plasma treatment apparatus, as wiring for connection covering between both could prevent trouble occurrences, such as connection by other things by exposing outside, and it unifies compactly and the whole device was referred to as that wearing use to a robot is also attained.

[0015]

[Embodiment of the Invention] Hereafter, an embodiment of the invention is described based on a drawing. The vertical section front view with which the side view and drawing 2 in which a 1st embodiment of the plasma treatment apparatus which drawing 1 requires for this invention is shown met the bottom view, and drawing 3 met the A-A line of drawing 1, and drawing 4 are the enlarged drawings of the important section of drawing 3.

[0016] The atmospheric pressure plasma treatment apparatus 20 in this 1st embodiment, On both sides of the thickness direction (the direction of x-x of drawing 3) of the high voltage electrode 1 formed in inner substance batten plate shape, and this high voltage electrode 1, fundamentally, respectively, The earth electrodes 3 and 3 of the batten plate shape of the rear surface couple by which isolated electrically and ground grounding was carried out to the above-mentioned high voltage electrode 1 by carrying out a placed opposite on both sides of the band-like electric insulating plates 2 and 2, such as a 4 fluoridation resin board, Among these high voltage electrodes 1, the earth electrodes 3 and 3, and the electric insulating plates 2 and 2, by the end part side of a short side direction (drawing 3 and the direction of z-z of drawing 5) between the high voltage electrode 1 and the earth electrodes 3 and 3. It consists of the covering casings 4, such as a product made from aluminum formed in the shape of angle U type so that the whole except the below-mentioned discharge gaps 15 and 15 and the mixing reaction gas blow-off passages 16 and 16 which are formed might be surrounded.

[0017] The end portion 1A of the short side direction (the direction of z-z of drawing 3) of the above-mentioned high voltage electrode 1 is formed in the shape of [ used as an inclined plane which is approached gradually ] an approximately isosceles triangle, so that the both side surfaces 1a and 1a approach a tip part, as shown in drawing 3 and drawing 4, and the tip part is formed in the circular curving surface 1b. The both-sides inclined planes 1a and 1a and the tip curving surface 1b of this approximately isosceles triangle-like portion 1A are covered with the insulator 9 formed of ceramic coating.

[0018] On the other hand, inside each inner substance of the earth electrodes 3 and 3 of the above-mentioned couple, As shown in drawing 5, the hole covering the overall length of an electrode long side direction (the direction of y-y of drawing 5) -- dawn processing and its hole -- by press fit immobilization (refer to drawing 6) of the plug 5 to both ends. While the reactant gas supply paths 6 and 6 which supply mixing reaction gas with the reactant gas containing the fluorine-containing compound gas of inactive gas, oxygen, or a fluorocarbon system containing gaseous helium or hydrogen under atmospheric pressure make an electrode long side direction meet and are formed, the hole covering the overall length of an electrode long side direction in the inside of the inner substance above these reactant gas supply paths 6 and 6 -- dawn processing and its hole -- the passages 8 and 8 for cooling water flows in the state where it is parallel with the above-mentioned reactant gas supply paths 6 and 6 by press fit immobilization (refer to drawing 6) of the plug 7 to both ends are formed.

The passage 18 for cooling water flows as well as the passage 8 for cooling water flows of the above-mentioned earth electrode 3 is formed also in the inside of the inner substance of the above-mentioned high voltage electrode 1.

[0019] As shown in drawing 3, drawing 4, and drawing 6, the inclined planes 3a and 3a which counter the both-sides inclined planes 1a and 1a of the approximately isosceles triangle-like portion 1A of the above-mentioned high voltage electrode 1 by a parallel condition are formed in the end part [ of the short side direction (the direction of z-z) of the earth electrodes 3 and 3 of the above-mentioned couple ] 3A, and A [ 3 ] side, respectively. Slitting is provided in the portion except a base end and the both ends of a long side direction among these inclined planes 3a and 3a. The discharge gaps 15 and 15 and the mixing reaction gas blow-off passages 16 and 16 are formed, respectively between the inclined plane partial 3a' cut deeply, 3a', and the both-sides inclined planes 1a and 1a of the approximately isosceles triangle-like portion 1A of the above-mentioned high voltage electrode 1. And the blow-off part 17 towards the processed material surface is formed in the downstream of these blow-off passages 16 and 16. The intersecting angles theta of the both-sides inclined planes 1a and 1a of the approximately isosceles triangle-like portion 1A by the side of the short side direction end of the high voltage electrode 1. The gas streams which pass through the both-sides discharge gaps 15 and 15 and the blow-off passages 16 and 16, and blow off are set as the angle which collides and joins rather than the blow-off part 17 in the downstream position of a jet direction (the direction of arrow w of drawing 4).

[0020] Inside the end parts 3A and 3A of the short side direction of the above-mentioned earth electrodes 3 and 3, respectively, Two or more mixing reaction gas blowout hole 10 -- and 10 -- in which separate regular intervals to an electrode long side direction, one end makes free passage connection in the above-mentioned reactant gas supply path 6, and the other end carries out an opening to inclined plane partial 3a' and 3a' are formed, these -- a blowout hole -- ten -- ten -- from -- the above -- a high voltage electrode -- one -- an inclined plane -- one -- a -- one -- a -- a couple -- an earth electrode -- three -- three -- an inclined plane -- a portion -- three -- a -- ' -- three -- a -- ' -- between -- forming -- having -- both sides -- a discharge gap -- 15 -- 15 -- and -- blow off -- a passage -- 16 -- 16 -- a mixing reaction -- gas -- introducing -- passing -- making -- while. The gas stream which is generated with generating of the glow discharge plasma in the discharge gaps 15 and 15 by impressing high frequency voltage to the high voltage electrode 1 and which includes an activity excitation kind chemically. It is constituted so that it may spout to linear shape (what is called the plasma flare is included hereafter) on the surface of a processed material from the blow-off part 17 through the both-sides blow-off passages 16 and 16.

[0021] Next, the using form of the atmospheric pressure plasma treatment apparatus 20 and operation by a 1st embodiment constituted as mentioned above are explained. As shown in drawing 7, the resin sheet materials 13, such as PTFE which is an example of a processed material, are laid in a horizontal position, and it is used for the upper part of the conveying path mid-position of the conveyor 14 in which continuous carrying is possible, changing the installation immobilization of the atmospheric pressure plasma treatment apparatus 20 into a crossing state. And, carrying out level conveyance of the resin sheet material 13 by above-mentioned conveyor 14. Mixing reaction gas is supplied to the above-mentioned reactant gas supply paths 6 and 6 under atmospheric pressure or the pressure near the atmospheric pressure (weak decompression or weak application of pressure), By impressing high frequency voltage (10 kHz - 500 MHz) to the above-mentioned high voltage electrode 1, while introducing this mixing reaction gas into two or more gas blow-off hole 10 -- and the

discharge gap parts 15 and 15 formed between the high voltage electrode 1 and the earth electrodes 3 and 3 through 10 --, The above-mentioned discharge gaps 15 and 15 are made to generate glow discharge plasma under atmospheric pressure, The ion generated by this plasma, which radical reactive gas style that includes an activity excitation kind chemically, Namely, by pouring the plasma flare towards the blow-off part 17 through the both-sides blow-off passages 16 and 16, and making linear shape blow off from this blow-off part 17 towards the surface of the resin sheet material 13, It becomes the plasma flare of the straight line shape which is not which carries out collision unification of these jet plasma flare mutually on the surface of the resin sheet material 13, and breaks off possible to make it act uniformly throughout the surface of the resin sheet material 13, and by this. The surface of the resin sheet material 13 can be reformed to hydrophilic nature, and the paint and the paste condition of ink over the resin sheet material 13, and an adhesive property can be improved remarkably.

[0022]Face constituting the PURAZU processing unit 20 which performs the above surface treatment operations, and in this invention. The single inner substance batten-plate-shape high voltage electrode 1, the supply paths 6 and 6 of mixing reaction gas and two or more mixing reaction gas blowout hole 10 --, and 10-- are formed, And only by piling up the earth electrodes 3 and 3 of a couple in which the inclined planes 3a and 3a which counter the both-sides inclined planes 1a and 1a of the approximately isosceles triangle-like portion 1A of the high voltage electrode 1, respectively were formed in the end part side of a short side direction on both sides of the electric insulating plates 2 and 2, It becomes possible to constitute the polar zone by which the linear shape thin planate discharge gaps 15 and 15 and the mixing reaction gas blow-off passages 16 and 16 were formed in both sides, and since the composition of the whole polar zone is dramatically easy in this way, sharp reduction of a manufacturing cost can be aimed at. Since it is the composition which the power loss accompanying abnormal discharge, such as a spark and arc discharge, does not produce easily in the bottom of atmospheric pressure or the pressure near the atmospheric pressure, While it is possible to make the discharge gaps 15 and 15 generate glow discharge plasma with sufficient stability, always proper in the predetermined surface treatment by plasma, since the plasma flare which blows off from the blow-off passages 16 and 16 of both sides is able to carry out collision unification, to be a straight line and to form a uniform plasma flare line in the longitudinal direction -- it can be made to carry out uniformly and very efficiently

[0023]Since the passages 8, 8, and 18 for circulation of cooling water are especially formed by hole down processing inside [ of the earth electrodes 3 and 3 of a couple, and the batten-plate-shape high voltage electrode 1 ] inner substance, Although polar-zone composition is simplified and a manufacturing cost reduction effect is maintained, overheating of each electrodes 3, 3, and 1 when covering a long time and performing a surface treatment can be prevented, and improve efficiency by continuous processing can be planned.

[0024]drawing 8 shows a 2nd embodiment of the BURAZUMA processing unit concerning this invention -- it being a notch side view in part, and, The fundamental composition of the atmospheric pressure plasma treatment apparatus 30 in this 2nd embodiment is the same as that of a 1st embodiment, attaches the same or numerals same into a considerable portion as a 1st embodiment, omits those detailed explanation, and adds explanation only about a point of difference hereafter.

[0025]Since a matching circuit is constituted from this 2nd embodiment, the variable condenser 11 and the coil 12 which enable adjustment of high frequency voltage arbitrarily are provided in the power supply path from the power supply terminal 19



provided in the high voltage electrode 1 side to the high voltage electrode 1, It consists of these variable condensers 11 and the coil 12, and the consistency machine for making an RF generator and the high voltage electrode 1 match is united with the plasma treatment apparatus 30.

[0026]In the atmospheric pressure plasma treatment apparatus 30 by a 2nd embodiment of the above, Since it is the composition that the consistency machine for matching with the RF generator and the high voltage electrode 1 which are carrying out the graphic display abbreviation into the covering casing 4 was built into one, It is possible to carry out direct attachment of a consistency machine and the power supply terminal 19 of the high voltage electrode 1 also electrically and physically, While reducing the power loss in a high frequency (not less than 100 kHz) high power operating mode and being able to attain stabilization of plasma treatment especially, As the wiring for connection covering between both could prevent trouble occurrences by exposing outside, such as connection by other things, and electric wave disclosure, and it unifies still more compactly and the whole device was referred to as that the wearing use to a robot is also attained, The flexibility of the using form of this plasma treatment apparatus can be extended.

[0027]Drawing 9 is an expansion vertical section front view of an important section showing a 3rd embodiment of the BURAZUMA processing unit concerning this invention, and the fundamental composition of the atmospheric pressure plasma treatment apparatus 30 in this 3rd embodiment is the same as that of a 1st embodiment, A different point the whole surface of the inclined planes 3a and 3a in the earth electrodes 3 and 3 of a couple, the both side surfaces 3b and 3b of the blow-off part 17, and the tip outside surfaces 3c and 3c, It is the point made to cover with insulator 9' formed of ceramic coating like the both-sides inclined planes 1a and 1a and the tip curving surface 1b in the high voltage electrode 1, and the numerals same into a considerable portion identically to a 1st embodiment are attached with other composition, and those detailed explanation is omitted.

[0028]In the atmospheric pressure plasma treatment apparatus 30 by a 3rd embodiment of the above, it is possible to ensure pre-insulation so that a spark may not occur between the high voltage electrode 1 and the earth electrodes 3 and 3 of a couple, and to heighten the protective effect of an electrode further.

[0029]

[Effect of the Invention]As mentioned above, while being able to generate glow discharge plasma stable also under atmospheric pressure or the pressure near the atmospheric pressure according to this invention, The gas streams which are generated by this plasma and which include an activity excitation kind chemically. It is made to blow off from the blow-off part of the two blow-off passage downstream of the inclination posture formed as the tip side so that it might approach towards the surface of a processed material, Since the gas stream of the straight line shape which is not which breaks off by the collision of these jet gas styles can be made to act uniformly throughout the surface of a processed material, a predetermined surface treatment can be made to carry out to an emergency efficiently properly uniformly in a usual state.

[0030]Moreover, a single inner substance batten-plate-shape high voltage electrode, and the supply path and two or more mixing reaction gas blowout holes of mixing reaction gas are formed structurally, And only by piling up the earth electrode of a couple in which the inclined plane which counters the both-sides inclined plane of the approximately isosceles triangle-like portion of a high voltage electrode, respectively was formed in the end part side of a short side direction on both sides of an electric

insulating plate, Constituting is [ the polar zone provided with the discharge gap, the reactant gas supply function, and the linear shape gas stream jet function ] possible, and from \*\*. A small weight saving and low-cost-izing with the whole device remarkable compared with the processing unit by low-pressure glow discharge plasma, That ease of the nest of a production process the expansion of applicability to a variety of [ area, thickness, shape, etc. ] processed materials and in-line can be planned from the first, Even if compared with the atmospheric pressure plasma treatment apparatus already proposed from before as a thing of a gestalt which turns a gas stream on the surface of a processed material, and makes approximately linear shape blow off, the composition of the whole polar zone is dramatically easy, and sharp reduction of a manufacturing cost can be aimed at. And since it is the composition which the power loss accompanying abnormal discharge, such as a spark and arc discharge, does not produce easily, it is easy to stabilize generating of the glow discharge plasma under atmospheric pressure, and the effect that the efficiency of the predetermined surface treatment by plasma can be raised much more is done so. [0031]It adds to the above-mentioned effect by adopting the composition [ like ] according to claim 2, By being able to perform positive pre-insulation which the generation cause of a spark does not produce in an electrode, being able to heighten the protective effect of an electrode, and being able to aim at improvement in endurance, and adopting the composition [ like ] according to claim 3. Overheating of an electrode when covering a long time and performing a surface treatment can be prevented, and a predetermined surface treatment can be performed efficiently continuously.

[0032]When adopting the composition [ like ] according to claim 4 in the plasma treatment apparatus of the above-mentioned composition, Can carry out collision unification of the gas streams on the surface of a processed material, can attain equalization of a surface treatment, and the further improvement in processing efficiency, and like a statement to claim 5 further again, When it has composition which incorporated the consistency machine in the covering casing at one, It is possible to carry out direct attachment of a consistency machine and the power supply terminal of an electrode also electrically and physically, While reducing the power loss in a high frequency (not less than 100 kHz) high power operating mode and being able to attain stabilization of plasma treatment especially, Free nature can be given to the using form of this plasma treatment apparatus, as the wiring for connection covering between both could prevent trouble occurrences by exposing outside, such as connection by other things, and electric wave disclosure, and it unifies compactly and the whole device was referred to as that the wearing use to a robot is also attained.

[Claim 1]On both sides of an electric insulating plate, a placed opposite is carried out to both sides of a thickness direction of a high voltage electrode currently formed in inner substance batten plate shape by earth electrode of a couple, respectively, and an end side portion of a short side direction of the above-mentioned batten-plate-shape high voltage electrode, While being formed in the shape of [ used as an inclined plane which is approached gradually ] an approximately isosceles triangle so that the both side surfaces approach a tip part, inside an earth electrode of the above-mentioned couple, While a supply path of mixing reaction gas with a reactant gas containing fluorine-containing compound gas of inactive gas, oxygen, or a fluorocarbon system which makes the long side direction meet and contains helium or hydrogen at least is formed, An inclined plane which makes a both-sides inclined plane of an approximately isosceles triangle-like portion of the above-mentioned high voltage

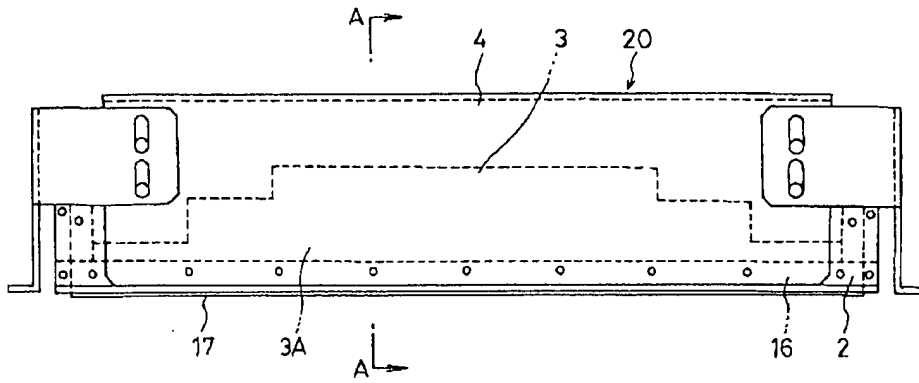
electrode counter the end part side of a short side direction of an earth electrode of these couples, respectively, and constitutes a discharge gap and a mixing reaction gas blow-off passage is formed, And the opening of two or more mixing reaction gas blowout holes which separated and formed an interval in a long side direction of each earth electrode in the above-mentioned reactant gas supply path so that free passage connection might be made is carried out to an inclined plane of an earth electrode of these couples, At least one side of the whole surface including the whole surface including a both-sides inclined plane of an approximately isosceles triangle-like portion of the above-mentioned high voltage electrode and an inclined plane of an earth electrode of a couple is covered with an insulator, While making a both-sides discharge gap of formation between inclined planes of the above-mentioned two electrodes, and a mixing reaction gas blow-off passage introduce and pass the above-mentioned mixing reaction gas under atmospheric pressure or a pressure near the atmospheric pressure from two or more above-mentioned gas blowout holes, By impressing high frequency voltage to the above-mentioned two electrodes, A plasma treatment apparatus constituting so that it may spout to linear shape on the surface of a processed material from a blow-off part which provided a gas stream which makes the above-mentioned both-sides discharge gap generate glow discharge plasma, and is generated by this plasma, and which includes an activity excitation kind chemically in the downstream of a both-sides blow-off passage.

[Claim 2]The plasma treatment apparatus according to claim 1 with which an insulator which covers at least one side of the whole surface including the whole surface including a both-sides inclined plane of an approximately isosceles triangle-like portion by the side of an end of a short side direction of the above-mentioned batten-plate-shape high voltage electrode and an inclined plane of an earth electrode of a couple is formed of ceramic coating.

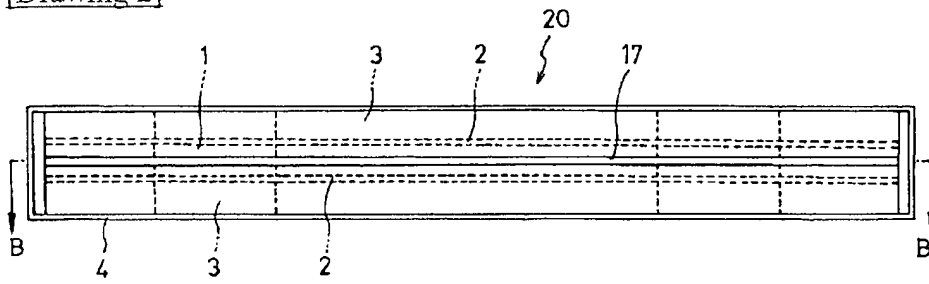
[Claim 3]The plasma treatment apparatus according to claim 1 or 2 with which an inside of an earth electrode of the above-mentioned couple and an inner substance batten-plate-shape high voltage electrode is made to meet those long side directions, respectively, and a passage for cooling water flows is formed.

[Claim 4]Intersecting angles of a both-sides inclined plane of an approximately isosceles triangle-like portion by the side of an end of a short side direction of the above-mentioned batten-plate-shape high voltage electrode, The plasma treatment apparatus according to any one of claims 1 to 3 set as an angle which the gas streams which pass through a both-sides discharge gap and a blow-off passage, and blow off collide and join rather than the above-mentioned blow-off part in a jet direction downstream position.

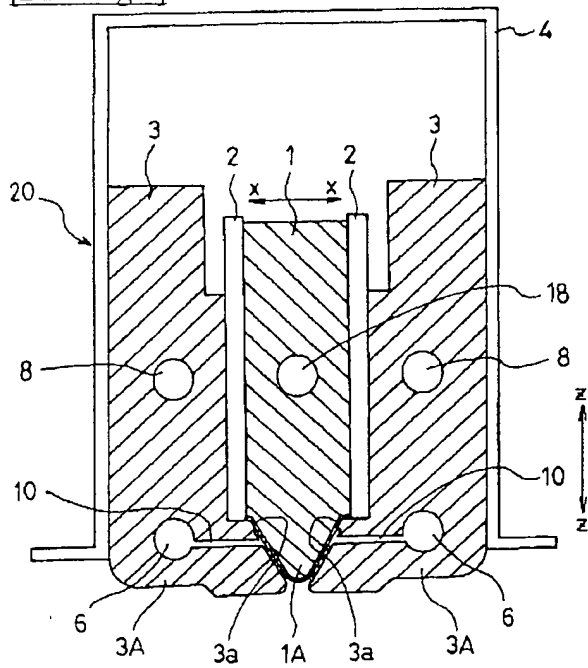
[Claim 5]The plasma treatment apparatus according to any one of claims 1 to 4 with which a covering casing which surrounds the above-mentioned high voltage electrode, an earth electrode, and an insulator is provided, and a consistency machine which adjusts an RF generator and a high voltage electrode in this covering casing is built into one.



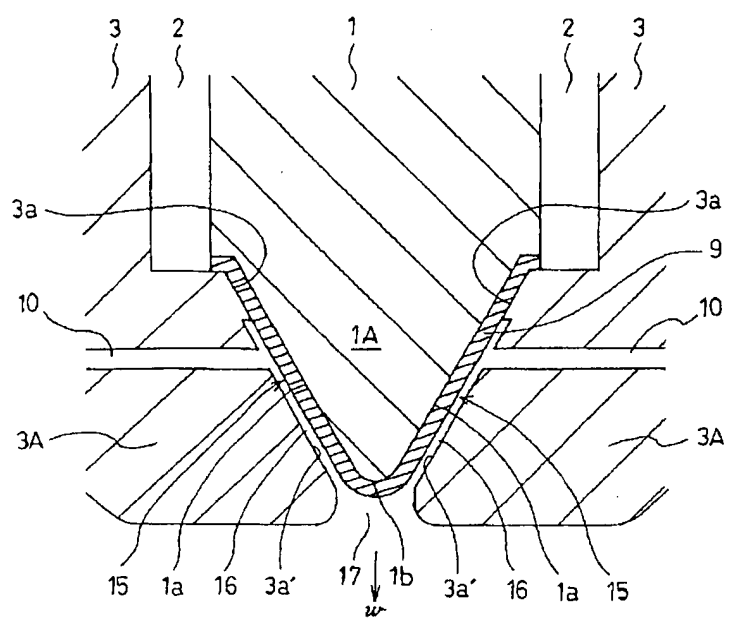
[Drawing 2]



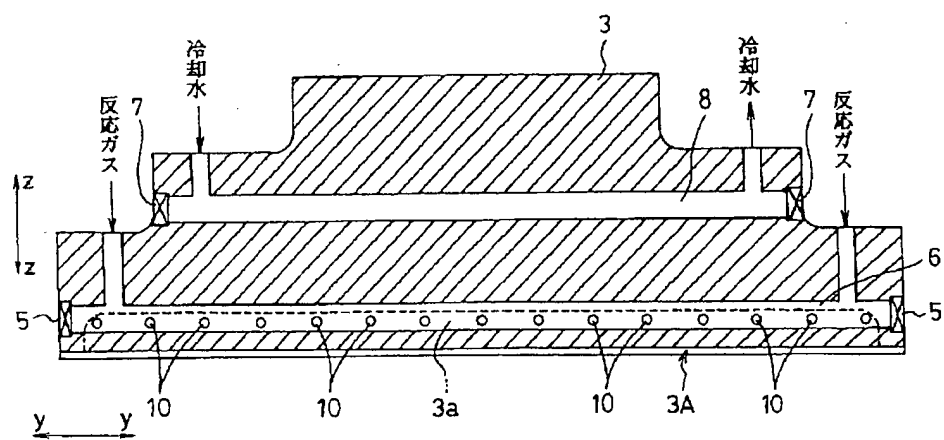
[Drawing 3]



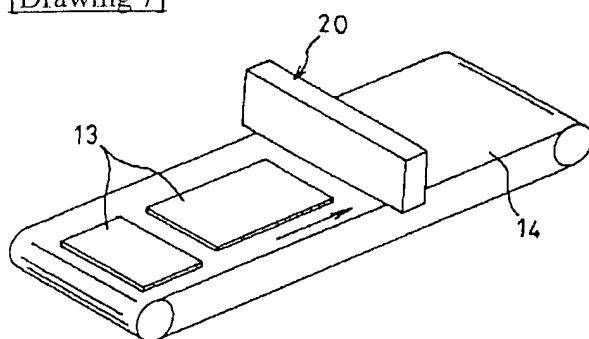
[Drawing 4]



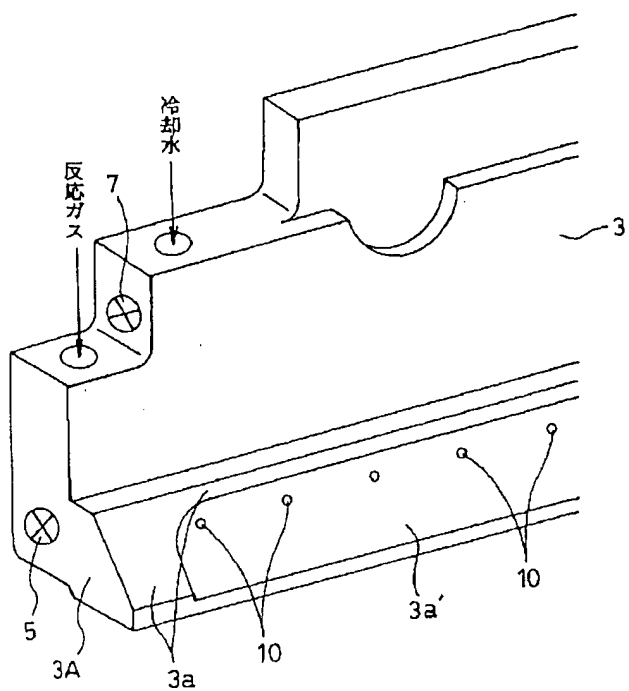
[Drawing 5]



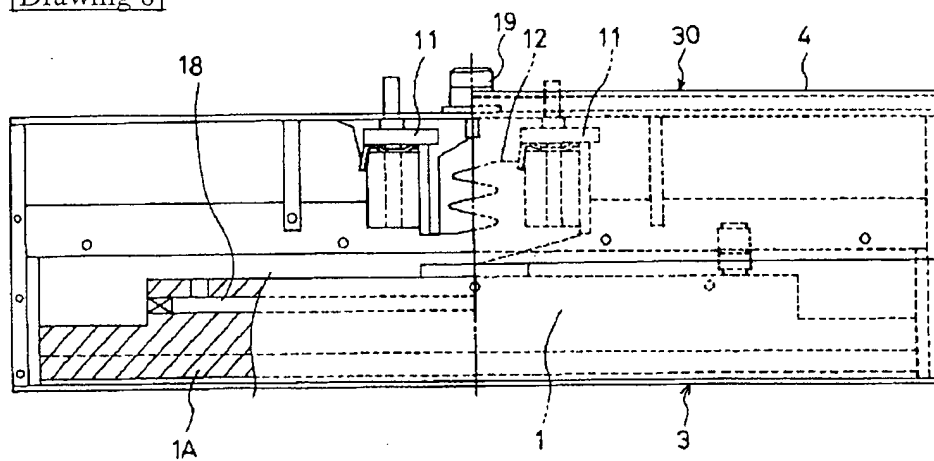
[Drawing 7]



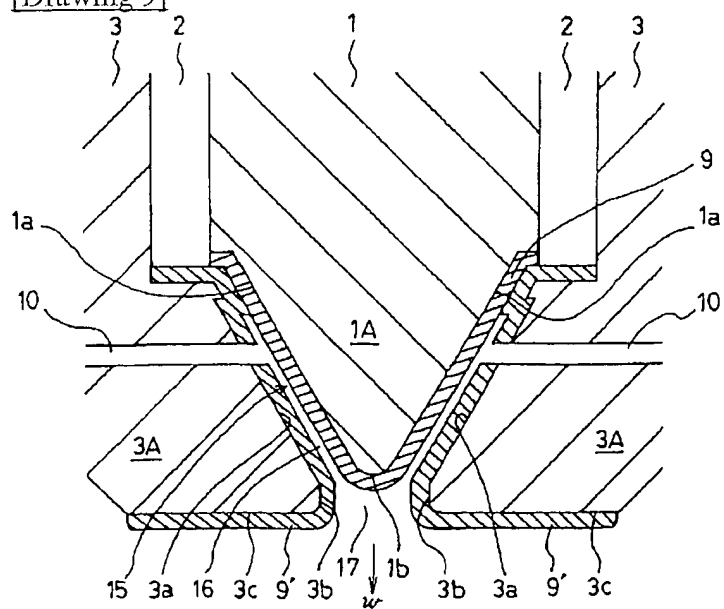
[Drawing 6]



[Drawing 8]



[Drawing 9]



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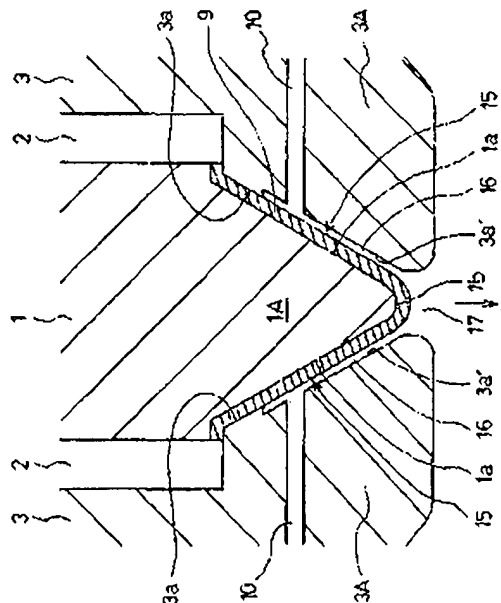
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(54) 発明の名称 プラズマ処理装置

(57) 要約

【課題】 装置全体の小型化、多種多様な被処理物に対する適用性の拡充及び生産プロセスのインラインへの組み込みの容易性だけでなく、電極部構成を簡単にして製作コストの大幅な低減が図れ、しかも、所定の表面処理を適正均一にかつ非常に効率よく行なえるようにする。

【解決手段】 中実帯板状に形成された高压電極1とそれの厚み方向の両側に絶縁板2、2を挟んで対向配置された一対の接地電極3、3とを備え、高压電極1の短辺方向の一端部分1Aを先端部ほど漸次接近するような傾斜面1a、1aを持つ略二等辺三角形形状に形成する一方、中実内部に反応ガス供給通路6が形成されている接地電極3、3の幅方向一端部3A、3A側に、高压電極1側の両側傾斜面1a、1aに対向させて放電ギャップ15、15及び放電プラズマにより生成される化学的に活性な励起種を含むガス流の吹出し通路16、16を構成する傾斜面3a、3aが形成されている。



【特許請求の範囲】

【請求項1】 中実帯板状に形成されている高圧電極の厚み方向の両側にそれぞれ絶縁板を挟んで一対の接地電極が対向配置され、

上記帯板状高圧電極の短辺方向の一端側部分は、その両側面が先端部に近付くほど漸次接近するような傾斜面となる略二等辺三角形形状に形成されている一方、

上記一対の接地電極の内部には、その長辺方向に沿わせて少なくともヘリウムまたは水素を含む不活性ガスと酸素またはフルオロカーボン系の含フッ素化合物ガスを含む反応性気体との混合反応ガスの供給通路が形成されているとともに、これら一対の接地電極の短辺方向の一端側側面にはそれぞれ、上記高圧電極の略二等辺三角形形状部分の両側傾斜面に対向させて放電ギャップ及び混合反応ガス吹出し通路を構成する傾斜面が形成され、かつ、それら一対の接地電極の傾斜面には上記反応ガス供給通路に追従接続するように各接地電極の長辺方向に間隔を隔てて形成した複数個の混合反応ガス吹出し開口が開口され、また、上記高圧電極の略二等辺三角形形状部分の両側傾斜面を含む全面及び一対の接地電極の傾斜面を含む全面のうちの少なくとも一方が絶縁体で被覆されており、

上記複数個のガス吹出し開口から上記両電極の傾斜面間に形成の両側放電ギャップ及び混合反応ガス吹出し通路に上記混合反応ガスを大気圧もしくは大気圧近傍圧力で導入し通過させるとともに、上記両電極に高周波電圧を印加することにより、上記両側放電ギャップにグロー放電プラズマを発生させて該プラズマにより生成される化学的に活性な励起種を含むガス流を両側吹出し通路の下流側に設けた吹出し部から被処理物の表面に直線状に噴出するように構成していることを特徴とするプラズマ処理装置。

【請求項2】 上記帯板状高圧電極の短辺方向の一端側の略二等辺三角形形状部分の両側傾斜面を含む全面及び一対の接地電極の傾斜面を含む全面のうちの少なくとも一方を被覆する絶縁体は、セラミックコーティングにより形成されている請求項1に記載のプラズマ処理装置。

【請求項3】 上記一対の接地電極及び中実帯板状高圧電極の内部にはそれぞれ、それらの長辺方向に沿わせて冷却水循環用通路が形成されている請求項1または2に記載のプラズマ処理装置。

【請求項4】 上記帯板状高圧電極の短辺方向の一端側の略二等辺三角形形状部分の両側傾斜面の交差角度は、両側放電ギャップ及び吹出し通路を通過して噴出されるガス流同士が上記吹出し部よりも噴出方向下流位置で衝突し合流する角度に設定されている請求項1ないし3のいずれかに記載のプラズマ処理装置。

【請求項5】 上記高圧電極、接地電極及び絶縁体を包囲するカバーケーシングが設けられ、このカバーケーシング内には、高周波電源と高圧電極とを整合させる整合器が一体に組み込まれている請求項1ないし4のいずれ

かに記載のプラズマ処理装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明はプラズマ処理装置に関するもので、詳しくは、主としてポリエチレンやポリプロピレン、PTFE（ポリ四フッ化エチレン）などの撥水性を有する樹脂に塗料を塗布するか水性インクで印刷を施す際にその表面を親水性に改質したり、プラスチックの表面に酸素のプラズマ処理によって濡れ性を付与したり、ガラス、セラミックス、金属、半導体等の疎水性表面を親水化したり、表面に付着した有機物を洗浄したりするなどの表面処理を行なう場合に用いられるプラズマ処理装置に関するものである。

【0002】

【従来の技術】上記のような表面改質や有機物洗浄等の表面処理に用いられるプラズマ処理装置として、ヘリウムや水素等の不活性ガスと酸素やフルオロカーボン系の含フッ素化合物ガス等の反応性気体とを混合してなる反応ガスを大気圧もしくは大気圧近傍（弱減圧または弱加圧）圧力で高圧電極と接地電極との間に形成される放電部に導入し通過させるとともに両電極に高周波電圧を印加することにより放電部にグロー放電プラズマを発生させて該プラズマにより生成される化学的に活性な励起種を含むガス流を被処理物の表面に向け噴出させて所定の表面処理を行なうように構成された大気圧プラズマ処理装置として、例えば特許第2589599号公報や特許第2934852号公報に開示されたような構成のものが従来より既に提案されている。

【0003】これら従来より提案されているプラズマ処理装置は大気圧下での表面処理が実現可能であって、それ以前から採用されていた低圧グロー放電プラズマによる処理装置、例えば真空容器内に互いに対向状態で配置した高圧電極と接地電極との間の放電部に酸素等の放電用反応ガスを導入させて両電極に高周波電圧を印加することにより低圧グロー放電プラズマを発生させ、該プラズマにより生成される化学的に活性な励起種を含むガスによって接地電極上に設置保持させた被処理物の表面を処理するように構成されていたプラズマ処理装置に比べて、真空系を形成するための装置及び設備が不要であることから、装置全体の小型化および低コスト化が図れるとともに、被処理物を電極上に設置する必要もないので、被処理物の面積や厚み、形状に対応させやすく、多種多様な被処理物に対する表面処理に適用可能であり、また、生産プロセスのインラインへの組み込みも容易で生産性の向上も図れるといった利点を有している。

【0004】

【発明が解決しようとする課題】従来提案されているプラズマ処理装置のうち、前者の特許第2589599号公報に開示されている大気圧プラズマ処理装置は、一端が閉塞された箱状の放電部内に二重ダクト構造の反応ガ



ス供給通路を形成するとともに、箱状放電部内の開放下  
端部側に細板状の一对の高圧電極と接地電極とを絶縁材  
セパレータを介して複数対向配置してその電極間に上記  
反応ガス供給通路が開口接続される筒状の放電空間を形  
成させてなるもので、電極部の構成が非常に複雑に入り  
込んだものであることから、製作組立が非常に困難で、  
装置全体のコストが高価になるばかりでなく、スパーク  
やアーク放電などの異常放電が発生しやすく、この異常  
放電に伴う電力ロスにより大気圧下でのグロー放電プラ  
ズマの発生が不安定になりやすいという問題がある。

【0005】一方、後者の特許第2934852号公報  
に開示されている大気圧プラズマ処理装置は、単一の中  
実帯板状高圧電極を用い、その中実内部への孔明け加工  
及びその厚み方向の両側面へのスリット加工という汎用  
の加工手段と、高圧電極の厚み方向の両側に絶縁板を挟  
んで一对の接地電極を重ね合わせるという簡易な組立手  
段で混合反応ガスの供給機能及び略直線状のガス流噴出  
機能を備えた電極部を構成することが可能であり、前者  
の大気圧プラズマ処理装置に比べて、電極部全体の構成  
が非常に簡単で、製作コストの低減が図れるとともに、  
スパークなどの異常放電に伴う電力ロスも抑制可能であ  
る。

【0006】しかしながら、後者の特許第293485  
2号公報に開示されている大気圧プラズマ処理装置で  
は、中実帯板状高圧電極の厚み方向の両側面それぞれ  
に、略半円形状の複数個のスリット状ガス吹出し穴を高  
圧電極の長辺方向に沿って断片的に形成し、これら厚み  
方向両側面のスリット状ガス吹出し穴を、長手方向に沿  
って互い違いに位置するように配置することで、放電プ  
ラズマの発生に伴い生成された化学的に活性な励起種を  
含むガス流を被処理物の表面に略直線状に噴出するよう  
に構成されたものであり、高圧電極の厚み方向両側面そ  
れぞれに複数個の略半円形状のスリット状ガス吹出し穴  
を両側の穴が長辺方向に沿って互い違いに位置するよう  
に形成するといった具合に、汎用の加工手段といえども  
多大かつ高精度な製作加工技術を要し、製作コストの低  
減にも限界がある。また、全体的には被処理物の表面に  
対してガス流が略直線状に噴出されるものの、実際には  
高圧電極の厚み方向両側面に断片的に略半円形状に形成  
されているスリット状ガス吹出し穴から噴出されるもの  
であるために、各吹出し穴から噴出されるガス流を途切  
れなく一直線状に形成させることが難しく被処理物の  
表面処理にばらつきが発生しやすいため、そのようなばら  
つきをなくするためには、被処理物の送り速度を遅くす  
る必要があり、処理効率の面で改良の余地が残されてい  
る。

【0007】本発明は上記のような実情に鑑みてなされ  
たもので、装置全体の小型化、多種多様な被処理物に対  
する適用性の拡充及び生産プロセスのインラインへの組  
込みの容易性を図ることができるのはもとより、電極部

の構成が非常に簡単で製作コストの大幅な低減を達成で  
きるとともに、異常放電による電力ロスも抑制でき、し  
かも、噴出ガス流を被処理物表面に確実に一直線に形成  
させて所定の表面処理を均一に、かつ非常に効率よく行  
なうことができるプラズマ処理装置を提供することを目  
的としている。

【0008】

【課題を解決するための手段】上記目的を達成するため  
に、本発明に係るプラズマ処理装置は、中実帯板状に形  
成されている高圧電極(1)の厚み方向(x-x方向)  
の両側にそれぞれ絶縁板(2)、(2)を挟んで一对の  
接地電極(3)、(3)が対向配置され、上記帯板状高  
圧電極(1)の短辺方向(z-z方向)の一端側部分  
(1A)は、その両側面が先端部に近づくほど漸次接近  
するような傾斜面(1a)、(1a)となる略二等辺三  
角形状に形成されている一方、上記一对の接地電極  
(3)、(3)の内部には、その長辺方向(y-y方  
向)に沿わせて少なくともヘリウムまたは水素を含む不  
活性ガスと酸素またはフルオロカーボン系の含フッ素化  
合物ガスを含む反応性気体との混合反応ガスの供給通路  
(6)が形成されているとともに、これら一对の接地電  
極(3)、(3)の短辺方向(z-z方向)の一端部側  
にはそれぞれ、上記高圧電極(1)の略二等辺三角形状  
部分(1A)の両側傾斜面(1a)、(1a)に対向さ  
せて放電ギャップ(15)及び混合反応ガス吹出し通路  
(16)を構成する傾斜面(3a)、(3a)が形成さ  
れ、かつ、それら一对の接地電極(3)、(3)の傾斜  
面(3a)、(3a)には上記反応ガス供給通路(6)  
に追従接続するように各接地電極(3)、(3)の長辺  
方向(y-y方向)に間隔を隔てて形成した複数個の混  
合ガス吹出孔(10)が開口され、また、上記高圧電極  
(1)の略二等辺三角形状部分(1A)の両側傾斜面  
(1a)、(1a)を含む全面及び一对の接地電極  
(3)、(3)の傾斜面(3a)、(3a)を含む全面  
のうちの少なくとも一方が絶縁体(9)で被覆されてお  
り、上記複数個のガス吹出孔(10)から上記両電極  
(1)、(3)、(3)の傾斜面(1a)、(3a)間  
に形成の両側放電ギャップ(15)及び混合反応ガス吹  
出し通路(16)に上記混合反応ガスを大気圧もしくは  
大気圧近傍圧力下で導入し通過させるとともに、上記両  
電極(1)、(3)、(3)に高周波電圧を印加すること  
により、上記両側放電ギャップ(15)にグロー放電  
プラズマを発生させて該プラズマにより生成される化学  
的に活性な励起種を含むガス流を両側吹出し通路(1  
6)の下流側に設けた吹出し部(17)から被処理物  
(13)の表面に直線状に噴出するように構成している  
ことを特徴とするものである。

【0009】上記構成の本発明によれば、帯板状高圧電  
極の厚み方向の両側に絶縁板を挟んで一对の接地電極を  
重ね合わせるという簡易な組立手段で混合反応ガスの供

給機能及び一直線状のガス流噴出機能を備えた電極部を構成することが可能である。これによって、低圧グロー放電プラズマによる処理装置に比べて装置全体の小型化、面積や厚み、形状などが多種多様な被処理物に対する適用性の拡充及び生産プロセスのインラインへの組込みの容易性はもちろん、従来より提案の大気圧プラズマ処理装置に比べて、電極部全体の構成が非常に簡単であるとともに、加工工程の削減及び高精度な加工技術の不要化によって全体の製作コストの大幅な低減が図れる。また、スパークやアーク放電などの異常放電に伴う電力ロスが生じにくい構成であるから、大気圧下でのグロー放電プラズマの発生を安定化しやすい。

【0010】さらに、高压電極の短辺方向の一側側の略二等辺三角形部分の両側傾斜面に沿って形成される両放電ギャップ及び吹出し通路に導入され通過してグロー放電プラズマにより生成された化学的に活性な励起種を含むガス流同士を吹出し通路下流側の吹出し部から被処理物の表面に向けて噴出させることによって、それら噴出ガス流同士の衝突により途切れない一直線状のガス流を被処理物の表面全域に均等に作用させることが可能で、所定の表面処理を常に適正均一に、かつ、非常に効率よく行なわせることができる。

【0011】上述のように動作するプラズマ処理装置において、上記帯板状高压電極の短辺方向一側側の略二等辺三角形部分の両側傾斜面を含む全面及び一対の接地電極の傾斜面を含む全面のうちの少なくとも一方を被覆する絶縁体として、請求項2に記載のように、セラミックコーティングにより形成する手段を採用する場合は、両電極の対向傾斜面に対しスパークの発生原因が発生しないような確実な絶縁被覆を容易に行なえ、電極の保護効果を高めて耐久性の向上を図ることができる。

【0012】また、上記構成のプラズマ処理装置において、請求項3に記載のように、一対の接地電極及び中実帯板状高压電極の内部にそれぞれ、それらの長辺方向に沿わせて冷却水循環用通路を形成する場合は、二重ダクトなどの特別な構成を採用しなくても、反応ガス供給通路の場合と同様に孔明け加工によって冷却水循環用通路を各電極自体に形成することが可能で、電極部構成をより簡単にして製作コストの一層の低減を図りつつ、長時間に亘って表面処理を行なう際の電極過熱を防いで所定の表面処理を連続的に効率よく実行することが可能である。

【0013】また、上記構成のプラズマ処理装置において、請求項4に記載のように、上記帯板状高压電極の短辺方向一側側の略二等辺三角形部分の両側傾斜面の交差角度を、両側放電ギャップ及び吹出し通路を通過して噴出されるガス流同士が上記吹出し部よりも噴出方向下流位置で衝突し合流する角度に設定することによって、ガス流同士を被処理物の表面上で衝突合流させて表面処理の均一化及び処理効率の一段の向上を達成すること

とができる。

【0014】さらに、上記構成のプラズマ処理装置において、請求項5に記載のように、上記高压電極、接地電極及び絶縁体を包囲するカバーケーシングを設け、このカバーケーシング内に、高周波電源と高压電極とを整合させる整合器を一体に組み込んだ構成とすることによって、整合器と電極の給電端子とを電気的にも物理的にも直付けすることが可能で、特に、高周波(100KHz以上)高電力使用態様での電力ロスを低減しプラズマ処理の安定化が図れるとともに、両者間に亘る接続用配線が外部に露出することによる他物との引掛りなどのトラブル発生を防止でき、かつ、装置全体をコンパクトに一体化してロボットへの装着使用も可能となるといったように、該プラズマ処理装置の使用形態に自由性を持たせることができる。

【0015】

【発明の実施の形態】以下、本発明の実施の形態を図面にもとづいて説明する。図1は本発明に係るプラズマ処理装置の第1の実施形態を示す側面図、図2はその底面図、図3は図1のA-A線に沿った縦断正面図、図4は図3の要部の拡大図である。

【0016】この第1の実施形態における大気圧プラズマ処理装置20は、基本的に、中実帯板状に形成された高压電極1と、この高压電極1の厚み方向(図3のx-x方向)の両側にそれぞれ、四非化樹脂板など帯状の絶縁板2、2を挟んで対向配置することによって上記高压電極1に対し電気的に隔離してアース接地された表裏一対の帯板状の接地電極3、3と、これら高压電極1、接地電極3、3及び絶縁板2、2のうち短辺方向(図3及び図5のz-z方向)の一側部側で高压電極1と接地電極3、3との間に形成される後述の放電ギャップ15、15及び混合反応ガス吹出し通路16、16を除く全体を包囲するように角U字形状に形成されたアルミニウム製等のカバーケーシング4とからなる。

【0017】上記高压電極1の短辺方向(図3のz-z方向)の一側部分1Aは、図3及び図4に示すように、その両側面1a、1aが先端部に近づくほど漸次接近するような傾斜面となる略二等辺三角形形状に形成され、その先端部は円弧状の湾曲面1bに形成されている。この略二等辺三角形部分1Aの両側傾斜面1a、1a及び先端湾曲面1bは、セラミックコーティングにより形成される絶縁体9で被覆されている。

【0018】一方、上記一対の接地電極3、3の各中実内部には、図5に示すように、電極長辺方向(図5のy-y方向)の全長に亘る孔明け加工及びその両孔端部への径5の圧入固定(図6参照)によってヘリウムガスまたは水素を含む不活性ガスと酸素またはフルオロカーボン系の含フッ素化合物ガスを含む反応性気体との混合反応ガスを大気圧下で供給する反応ガス供給通路6、6が電極長辺方向に沿わせて形成されているとともに、該反

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応ガス供給通路6、6よりも上部の中実内部には、電極長辺方向の全長に亘る孔明け加工及びその孔両端部への栓7の圧入固定(図6参照)によって上記反応ガス供給通路6、6に並行する状態の冷却水循環用通路8、8が形成されている。なお、上記高压電極1の中実内部にも上記接地電極3の冷却水循環用通路8と同様に冷却水循環用通路18が形成されている。

【0019】また、上記一対の接地電極3、3の短辺方向(z-z'方向)の一端部3A、3A側にはそれぞれ、図3、図4及び図6に示すように、上記高压電極1の略二等辺三角形形状部分1Aの両側傾斜面1a、1aに平行状態で対向する傾斜面3a、3aが形成されている。これら傾斜面3a、3aのうち、基端部及び長辺方向の両端部を除く部分に切り込みが設けられており、その切り込まれた傾斜面部分3a'、3a'と上記高压電極1の略二等辺三角形形状部分1Aの両側傾斜面1a、1aとの間にそれぞれ放電ギャップ15、15及び混合反応ガス吹出し通路16、16が形成され、かつ、これら吹出し通路16、16の下流側に被処理物表面に向けての吹出し部17が形成されている。なお、高压電極1の短辺方向一端側の略二等辺三角形形状部分1Aの両側傾斜面1a、1aの交差角度θは、両側放電ギャップ15、15及び吹出し通路16、16を通過して噴出されるガス流同士が吹出し部17よりも噴出方向(図4の矢印w方向)の下流位置で衝突し合流する角度に設定されている。

【0020】さらに、上記接地電極3、3の短辺方向の一端部3A、3Aの内部にはそれぞれ、電極長辺方向に等間隔を隔てて、一端が上記反応ガス供給通路6に連続接続し他端が傾斜面部分3a'、3a'に開口する複数の混合反応ガス吹出し孔10…、10…が形成されており、これら吹出し孔10…、10…から上記高压電極1の傾斜面1a、1aと一対の接地電極3、3の傾斜面部分3a'、3a'間に形成される両側放電ギャップ15、15及び吹出し通路16、16に混合反応ガスを導入し通過させるとともに、高压電極1に高周波電圧を印加することにより、放電ギャップ15、15でのグロー放電プラズマの発生に伴い生成される化学的に活性な励起種を含むガス流(以下、プラズマフレアと称するものも含む)を両側吹出し通路16、16を通して吹出し部17から被処理物の表面に直線状に噴出するように構成されている。

【0021】次に、上記のように構成された第1の実施形態による大気圧プラズマ処理装置20の使用形態及び動作について説明する。図7に示すように、被処理物の一例であるPTFEなどの樹脂シート材13を水平姿勢に載置して連続搬送可能なコンベア14の搬送経路中間位置の上部に大気圧プラズマ処理装置20を横断状態に設置固定して使用される。そして、上記コンベア14によって樹脂シート材13を水平搬送させつつ、大気圧も

しくは大気圧近傍(弱減圧または弱加圧)圧力下で上記反応ガス供給通路6、6に混合反応ガスを供給し、この混合反応ガスを複数のガス吹出し孔10…、10…を通して高压電極1と接地電極3、3との間に形成される放電ギャップ部15、15に導入するとともに上記高压電極1に高周波電圧(10kHz~500MHz)を印加することによって、上記放電ギャップ15、15に大気圧下でグロー放電プラズマを発生させ、該プラズマにより生成されるイオン、ラジカルなどの化学的に活性な励起種を含む反応性ガス流、すなわち、プラズマフレアを両側吹出し通路16、16を通して吹出し部17に向けて流し、この吹出し部17から樹脂シート材13の表面に向け直線状に噴出させることによって、それら噴出プラズマフレア同士を樹脂シート材13の表面上で互いに衝突合流させて途切れのない一直線状のプラズマフレアを樹脂シート材13の表面全域に均等に作用させることが可能となり、これによって、樹脂シート材13の表面を親水性に改質して樹脂シート材13に対する塗料やインクののり具合や接着性を著しく改善することができる。

【0022】以上のような表面処理動作を行なうプラズマ処理装置20を構成するに際して、本発明では、単一の中実帯板状高压電極1と、混合反応ガスの供給通路6、6及び複数の混合反応ガス吹出し孔10…、10…が形成され、かつ、短辺方向の一端部側にはそれぞれ高压電極1の略二等辺三角形形状部分1Aの両側傾斜面1a、1aに対向する傾斜面3a、3aが形成された一対の接地電極3、3とを絶縁板2、2を挟んで重ね合わせるだけで、両側に薄い平面状で直線状の放電ギャップ15、15及び混合反応ガス吹出し通路16、16が形成された電極部を構成することが可能となり、このように電極部全体の構成が非常に簡単であることから、製作コストの大幅な低減が図れる。また、大気圧もしくは大気圧近傍圧力下においてもスパークやアーク放電などの異常放電に伴う電力ロスが生じにくい構成であるから、放電ギャップ15、15に安定よくグロー放電プラズマを発生させることが可能であるとともに、両側の吹出し通路16、16から噴出されるプラズマフレアが衝突合流されて一直線で、かつ、その長手方向に均一なプラズマフレアラインを形成することが可能であるために、プラズマによる所定の表面処理を常に適正均一にかつ非常に効率よく行なわせることができる。

【0023】特に、一対の接地電極3、3及び帯板状高压電極1の中実内部への孔明け加工によって冷却水の循環用通路8、8及び18が形成されているので、電極部構成を簡単にして製作コスト低減効果を保ちつつも、長時間に亘って表面処理を行なう時の各電極3、3、1の過熱を防いで連続処理による効率向上を図ることができる。

【0024】図8は本発明に係るプラズマ処理装置の第

2の実施形態を示す一部切欠き側面図であり、この第2の実施形態における大気圧プラズマ処理装置30の基本的な構成は第1の実施形態と同様であり、第1の実施形態と同一もしくは相当部分に同一の符号を付してそれらの詳しい説明を省略し、以下、相違点についてのみ説明を加える。

【0025】この第2の実施形態では、整合回路を構成するために、高圧電極1側に設けられた給電端子19から高圧電極1に至る給電経路に高周波電圧を任意に調整可能とするバリコン11及びコイル12が設けられており、これらバリコン11及びコイル12からなり、高周波電源と高圧電極1とをマッチングさせるための整合器がプラズマ処理装置30に一体化されている。

【0026】上記第2の実施形態による大気圧プラズマ処理装置30においては、カバーケーシング4内に図示省略している高周波電源と高圧電極1とのマッチングのための整合器が一体に組込まれた構成であるために、整合器と高圧電極1の給電端子19とを電気的にも物理的にも直付けすることが可能で、特に、高周波(100KHz以上)高電力使用態様での電力ロスを低減しプラズマ処理の安定化が図れるとともに、両者間に亘る接続用配線が外部に露出することによる他物との引掛りや電波漏洩などのトラブル発生を防止でき、かつ、装置全体を一層コンパクトに一体化してロボットへの装着使用も可能となるといったように、該プラズマ処理装置の使用形態の自由度を上げることができる。

【0027】図9は本発明に係るプラズマ処理装置の第3の実施形態を示す要部の拡大縦断正面図であり、この第3の実施形態における大気圧プラズマ処理装置30の基本的な構成は第1の実施形態と同様で、相違する点は、一対の接地電極3、3における傾斜面3a、3a、吹出し部17の両側面3b、3b及び先端外面3c、3cの全面も、高圧電極1における両側傾斜面1a、1a及び先端湾曲面1bと同様にセラミックコーティングにより形成される絶縁体9'で被覆させている点であり、その他の構成で第1の実施形態と同一もしくは相当部分には同一の符号を付してそれらの詳しい説明を省略する。

【0028】上記第3の実施形態による大気圧プラズマ処理装置30においては、高圧電極1と一対の接地電極3、3との間でスパークが発生しないように絶縁被覆を確実にして、電極の保護効果を一層高めることが可能である。

【0029】

【発明の効果】以上のように、本発明によれば、大気圧もしくは大気圧近傍の圧力下でも安定なグロー放電プラズマを発生させることができるとともに、このプラズマにより生成される化学的に活性な励起種を含むガス流同士を、先端側ほど近接するように形成された傾斜姿勢の二つの吹出し通路下流側の吹出し部から被処理物の表面に向けて噴出させ、それら噴出ガス流同士の衝突により

途切れのない直線状のガス流を被処理物の表面全域に均等に作用させることができるので、所定の表面処理を常に適正均一に、かつ、非常に効率よく行なわせることができる。

【0030】そのうえ、構造的には、単一の中実帯板状高圧電極と、混合反応ガスの供給通路及び複数個の混合反応ガス吹出孔が形成され、かつ、短辺方向の一端部側にはそれぞれ高圧電極の略二等辺三角形形状部分の両側傾斜面に対向する傾斜面が形成された一対の接地電極とを絶縁板を挟んで重ね合わせるだけで、放電ギャップ並びに反応ガス供給機能及び直線状のガス流噴出機能を備えた電極部を構成することが可能であるから、低圧グロー放電プラズマによる処理装置に比べて、装置全体の著しい小型軽量化および低コスト化、面積や厚み、形状などが多種多様な被処理物に対する適用性の拡充及び生産プロセスのインラインへの組み込みの容易性を図ることができるのはもとより、ガス流を被処理物の表面に向けて略直線状に噴出させる形態のものとして従来より既に提案されている大気圧プラズマ処理装置に比べても、電極部全体の構成が非常に簡単で、製作コストの大幅な低減を図ることができる。しかも、スパークやアーク放電などの異常放電に伴う電力ロスが生じにくい構成であるから、大気圧下でのグロー放電プラズマの発生を安定化しやすく、プラズマによる所定の表面処理の効率を一段と向上させることができるという効果を奏する。

【0031】また、請求項2に記載のような構成を採用することにより上記効果に加えて、電極にスパークの発生原因が生じない確実な絶縁被覆を行なえ、電極の保護効果を高めて耐久性の向上を図ることができ、また、請求項3に記載のような構成を採用することで、長時間に亘って表面処理を行なう時の電極の過熱を防いで所定の表面処理を連続的に効率よく実行することができる。

【0032】さらに、上記構成のプラズマ処理装置において、請求項4に記載のような構成を採用する場合は、ガス流同士を被処理物の表面で衝突合流させて表面処理の均一化及び処理効率の一段の向上を達成することができ、さらにまた、請求項5に記載のように、カバーケーシング内に整合器を一体に組み込んだ構成とする場合は、整合器と電極の給電端子とを電気的にも物理的にも直付けすることが可能で、特に、高周波(100KHz以上)高電力使用態様での電力ロスを低減しプラズマ処理の安定化が図れるとともに、両者間に亘る接続用配線が外部に露出することによる他物との引掛りや電波漏洩などのトラブル発生を防止でき、かつ、装置全体をコンパクトに一体化してロボットへの装着使用も可能となるといったように、該プラズマ処理装置の使用形態に自由度を持たせることができる。

【図面の簡単な説明】

【図1】本発明に係るプラズマ処理装置の第1の実施形態による大気圧プラズマ装置の側面図である。

【図2】図1の底面図である。

【図3】図1のA-A線に沿った縦断正面図である。

【図4】図3の要部の拡大図である。

【図5】図2のB-B線に沿った縦断側面図である。

【図6】第1の実施形態による大気圧プラズマ処理装置における接地電極の要部拡大斜視図である。

【図7】同上大気圧プラズマ処理装置の使用形態を示す概略斜視図である。

【図8】本発明に係るプラズマ処理装置の第2の実施形態による大気圧プラズマ処理装置の一部切欠き側面図である。

【図9】本発明に係るプラズマ処理装置の第3の実施形態による大気圧プラズマ処理装置の要部の拡大縦断正面図である。

【符号の説明】

1 高压電極

\* 1 A 略二等辺三角形形状部分

1 a, 1 a' 傾斜面

2, 2' 絶縁板

3 接地電極

3 A 幅方向一端部

3 a, 3 a' 傾斜面

4 カバーケーシング

6 反応ガス供給通路

8, 18 冷却水循環用通路

9, 9' セラミックコーティングによる絶縁体

10 混合反応ガス流吹出孔

13 樹脂シート材（被処理物）

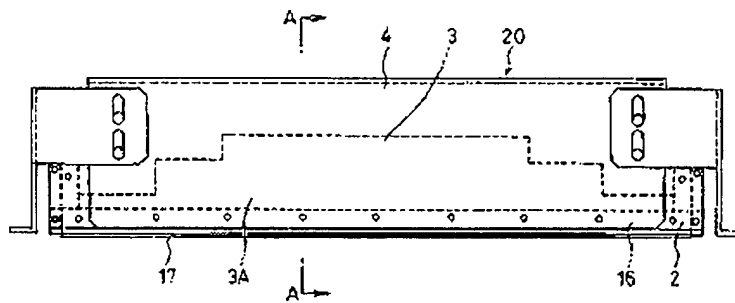
15 放電ギャップ

16 ガス流吹出し通路

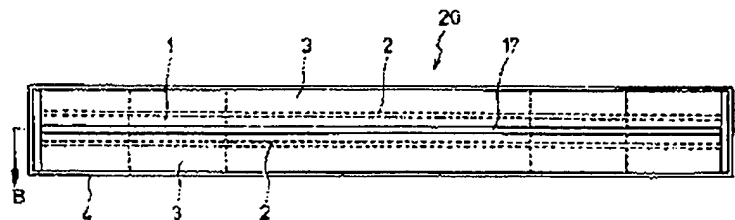
17 吹出し部

\*

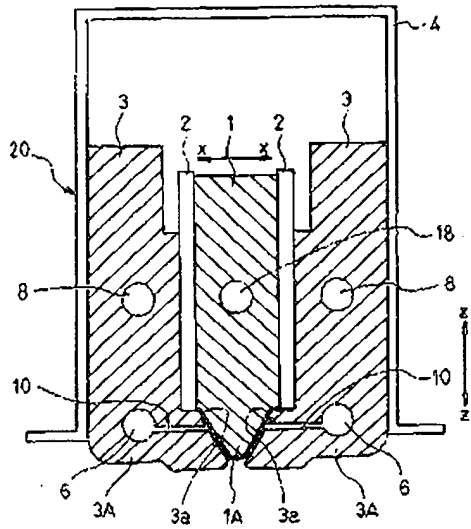
【図1】



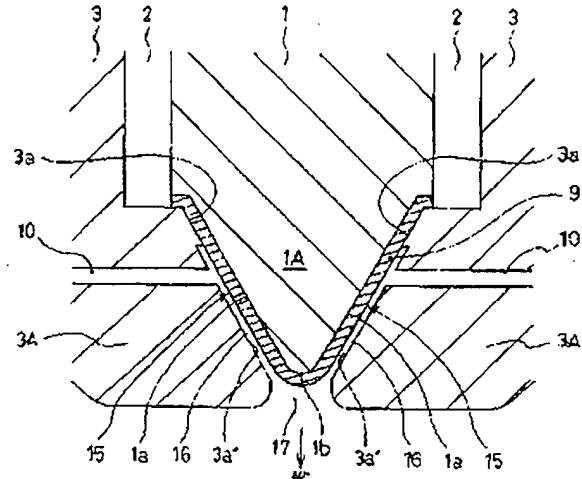
【図2】



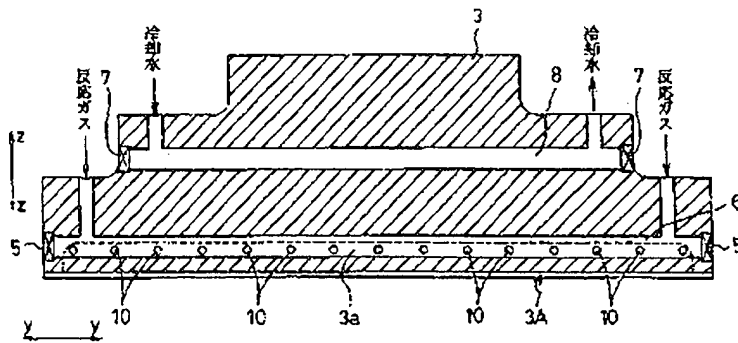
【図3】



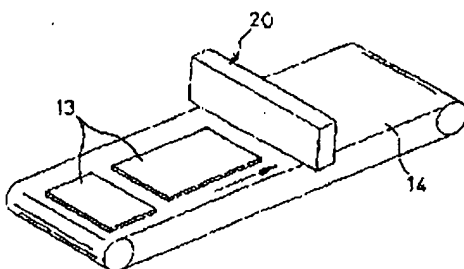
【図4】



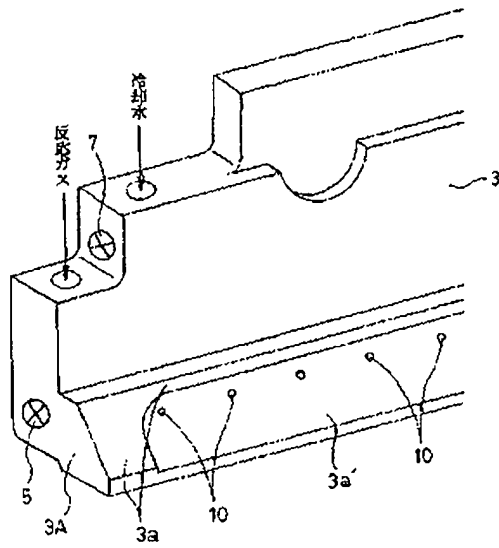
【図5】



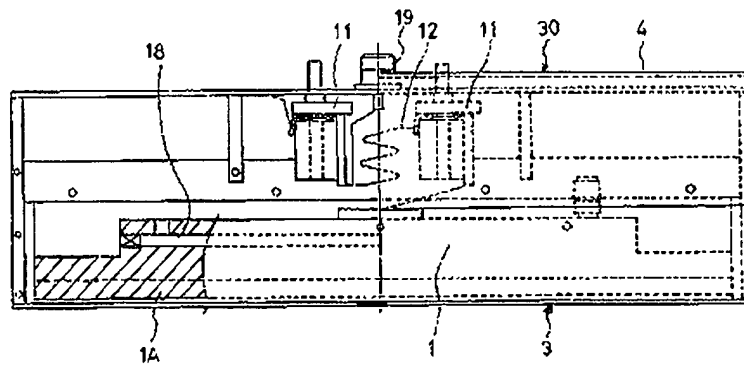
【図7】



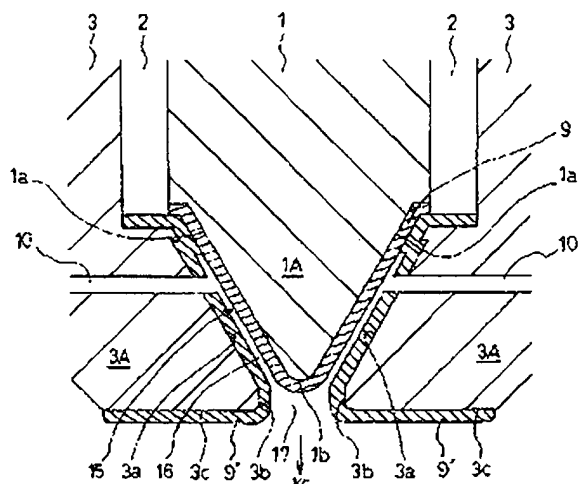
【図6】



【図8】



【図9】



フロントページの続き

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 DA26 DE23 EB08